4. Wastewater Disinfection & Buffer Zones

Needs to Know Criteria
▪ Disinfection levels for total coliform defined in the Wastewater Land Application Permit Rules
▪ Buffer zones
▪ Land uses of concern and buffer zones
▪ Guideline buffer zone distances
▪ Disinfection levels and buffer zone distances
▪ Onsite conditions affecting buffer zone requirements
▪ Three parts to buffer zone requirements
▪ General buffer zone distances between a land application site and residential areas, drinking water wellheads, and surface waters
▪ Spray drift containment
▪ Best management practices for wellheads
▪ Role of irrigation equipment and vegetative barriers in reducing buffer zones

Disinfection—to destroy disease-producing organisms—and buffer zones—to minimize public health impacts, nuisance conditions and aesthetic concerns—are important aspects of any wastewater land application site. Both are discussed in the following.

4.1 Disinfection

Disinfection is generally the last form of pretreatment prior to land application of wastewater. The purpose of wastewater effluent disinfection is to destroy disease-producing microorganisms or pathogens. As discussed in Section 1, pathogens can cause many illnesses, such as typhoid fever, amoebic dysentery and infectious hepatitis.

The disinfection process should be economical, operationally practical and environmentally acceptable. The three major types of disinfection used are the following:

- chlorination
- ultraviolet radiation
- ozone

Chlorination

Because of its simple feed and control procedures, its ability to disinfect wastewater with low dosages, and its relatively low cost, chlorination is the most prevalent form of disinfection in the United States today. However, heightened awareness of the safety issues and environmental concerns associated with chlorine use is decreasing its popularity.

Forms of Chlorine

Several forms of chlorine can be used in wastewater disinfection:

- liquid/gas chlorine (Cl_2) - available in pressurized containers that maintain chlorine in a liquid state;
- calcium hypochlorite ($Ca(OCl_2)$)—a white powder or tablet; and
- sodium hypochlorite ($NaOCl$)—a pale yellow solution in water.

Chlorine in either the gaseous or liquid state is considered to be 100% available chlorine for disinfection purposes. Calcium hypochlorite, purchased in powder or tablet form, generally contains approximately 65% or 70% available chlorine. Sodium hypochlorite is usually purchased as a solution containing approximately 15% available chlorine. (The manufacturer's label should contain this information.)

Chlorine Dosage

Chlorine reacts with many compounds present in wastewater. Nitrogen compounds (including ammonia) react with chlorine to produce chloramines. These chloramines are considered to be relatively effective disinfectants. However, many of the compounds formed when chlorine reacts with non-nitrogen compounds are ineffective as disinfectants.

Chlorine reacts with non-nitrogen compounds before it reacts with nitrogen compounds. Therefore, enough chlorine must be added to react with the non-nitrogen compounds and ensure that there is enough chlorine still available for the formation of chloramines. Less chlorine is required to disinfect a higher quality effluent than a poorer quality effluent because there are fewer compounds with which the chlorine may react.

Chlorine dosage is the amount of chlorine that is added to a given volume of wastewater. *Chlorine demand* is the amount of chlorine that is not available as a disinfectant because of reactions with various compounds in the effluent. *Chlorine residual* (Equation 4-1) is the amount of chlorine in the effluent that is available for disinfection after a specific contact time. A minimum chlorine residual must be maintained to ensure that enough chlorine has been added to meet all of the chlorine demand. The relationship between chlorine dosage, chlorine demand, and chlorine residual can be expressed as follows (although this is true only if the chlorine dose is equal to or greater than the demand):

$$\text{Chlorine residual} = \text{chlorine dose} - \text{chlorine demand}$$

Equation 4-1. Chlorine residual calculation.

Chlorine Measurement and Addition

Measurement of chlorine residuals must be performed by approved methods. Amperometric titration provides the most convenient and most repeatable results, but is more expensive than other methods. A less expensive method is the DPD test.

Factors affecting the effectiveness of chlorination include the following:

- injection point and method of mixing
- design of contact chambers
- contact time
- effectiveness of upstream treatment processes
- temperature
- dose rate and type of chemical
- pH
- the number and types of organisms present in the effluent

Chlorine contact chambers should be designed so that the chlorine injection point is below the surface of the effluent to prevent volatilization. Chambers should also be designed to prevent short-circuiting of effluent. Higher chlorine concentrations, longer contact times (chlorine contact basins should be designed for a minimum of 30 minutes of contact time), and higher temperatures increase the effectiveness of chlorination, while higher pH (above 7.0), total suspended solids, and organic content decrease effectiveness.

Methods of Chlorination

Chlorine disinfection is generally accomplished by one of the following methods:

- gas chlorination
- hypochlorination
- tablet chlorination

Gaseous chlorine is usually delivered by a vacuum-solution feed chlorinator that creates a vacumm, pulling chlorine into the water supply. Because this type of chlorinator uses pure chlorine, which is toxic, the manufacturer's operation instructions must be carefully followed. You should never attempt to operate a gas chlorinator without first reading the manufacturer's operation manual.

Hypochlorinators (Figure 4-1) are pumps or devices used to feed chlorine solutions made from sodium or calcium hypochlorite. The basic components are a storage reservoir or mixing tank, a metering pump, a feed-rate adjustment device, and an injection device.

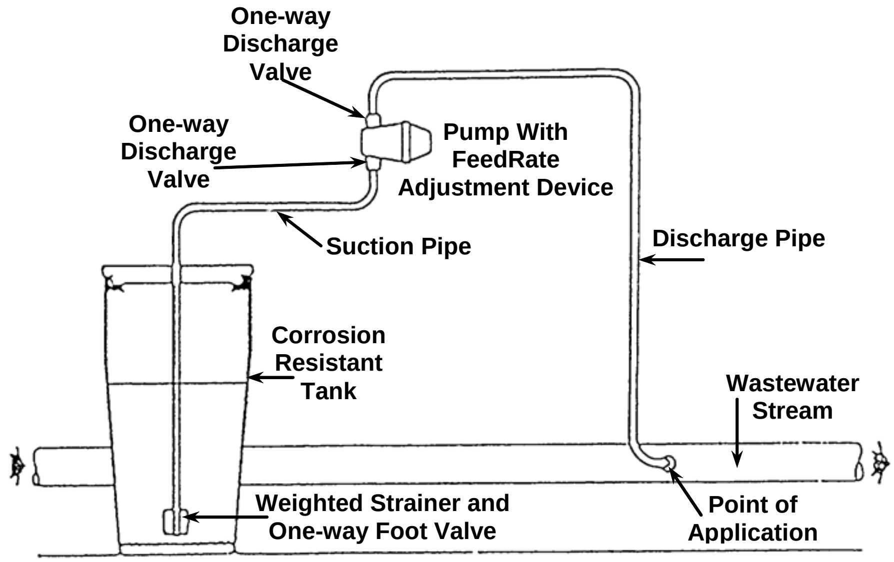

Figure 4-1. Typical hypochlorinator.

Tablet chlorinators (Figure 4-2) use calcium hypochlorite tablets (around 70% available chlorine). The chlorinator has several slotted tubes where the tablets are placed in vertical stacks. As wastewater flows through the slotted tubes, the tablets dissolve in the effluent stream. Dosage is determined by the number of tubes containing tablets and the height of water in the chlorinator.

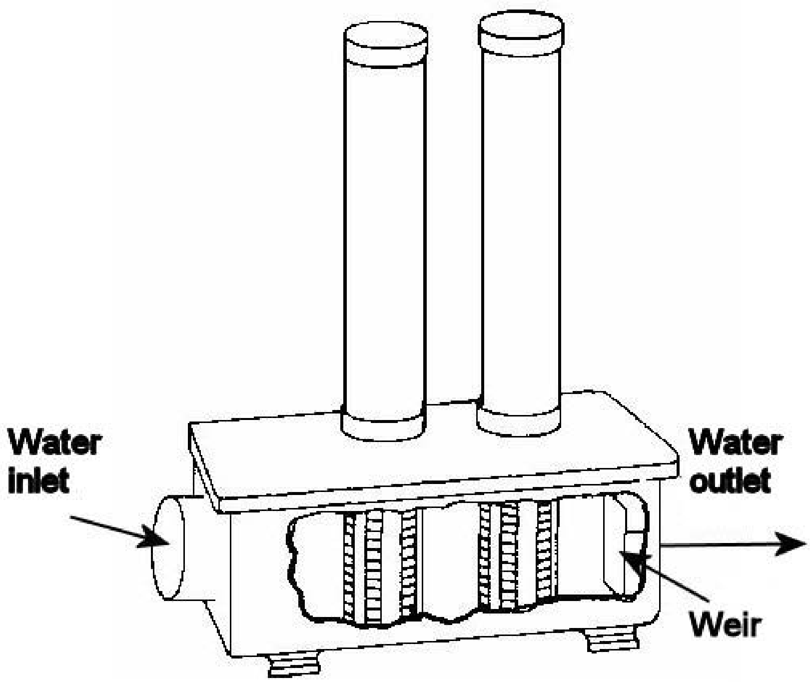

Figure 4-2. Tablet chlorinator (WEF 1985).

Leak Detection and Chlorine Safety

Chlorine is a highly toxic gas and is corrosive in moist atmospheres. Because of the corrosive nature of chlorine, leaks should be repaired as quickly as possible to prevent a minor leak from becoming a major leak. Small leaks can be found by using a rag soaked with an ammonia solution. A "squeeze bottle" filled with ammonia water may also be used. The vapors from the cloth or squeezed from the bottle will form a white cloud to indicate a chlorine leak. Care must be taken to avoid spraying ammonia water on any leak or touching the ammonia-soaked cloth to any metal.

As mentioned earlier, chlorine reacts with water to form hypochlorous acid. If inhaled, chlorine gas is absorbed by moisture that coats the lungs and destroys cell tissue. Chlorine that comes into contact with skin can cause mild to severe burns. If chlorine comes into contact with skin or clothing, the affected body parts should be flushed with water for at least 15 minutes. Symptoms of chlorine exposure include the following:

- burning of the eyes, nose, mouth and throat
- coughing and choking
- nausea and vomiting
- headache and dizziness

All enclosed areas that house chlorine cylinders or equipment should have operating leak detectors. These detectors should be located outside the enclosed area and their wiring should be checked regularly.

Chlorine should never be stored near gasoline, oils or similar materials; chlorine reacts violently with these substances. Water should never be applied to a chlorine leak, as the leak will only become larger. Do not store or use chlorine cylinders where they will be exposed to the sun.

When changing chlorine tanks, these minimum precautions must be followed:

- wear safety goggles, rubber gloves, and a long sleeved shirt
- have two operators present: one to perform the work and one to assist should a leak develop
- allow only trained personnel to enter a contaminated area

You must always remember that chlorine is a hazardous chemical and must be handled with respect. Every person working with chlorine should know the proper ways to handle it, should be trained in the use of appropriate respiratory protective devices and methods of detecting hazards, and should know what to do in case of emergencies. All facilities that use chlorine should develop an emergency response plan.

Note: The safety measures mentioned here are not all-inclusive, and the Occupational Safety and Health Administration (OSHA) should be contacted regarding specific chlorine safety regulations.

Ultraviolet Radiation

Ultraviolet (UV) radiation uses lamps that emit wavelengths of light that are invisible to humans. Ultraviolet radiation kills bacteria and viruses in wastewater effluent by destroying their cellular genetic material, thereby preventing cell replication. Unlike chlorine, UV radiation leaves no residual in the wastewater and adds nothing except energy that produces some heat. Ultraviolet (UV) light is generally considered as an alternative to chlorine disinfection when the permit requires very low or no chlorine residual or because of safety concerns. A typical ultraviolet disinfection unit is shown in Figure 4-3.

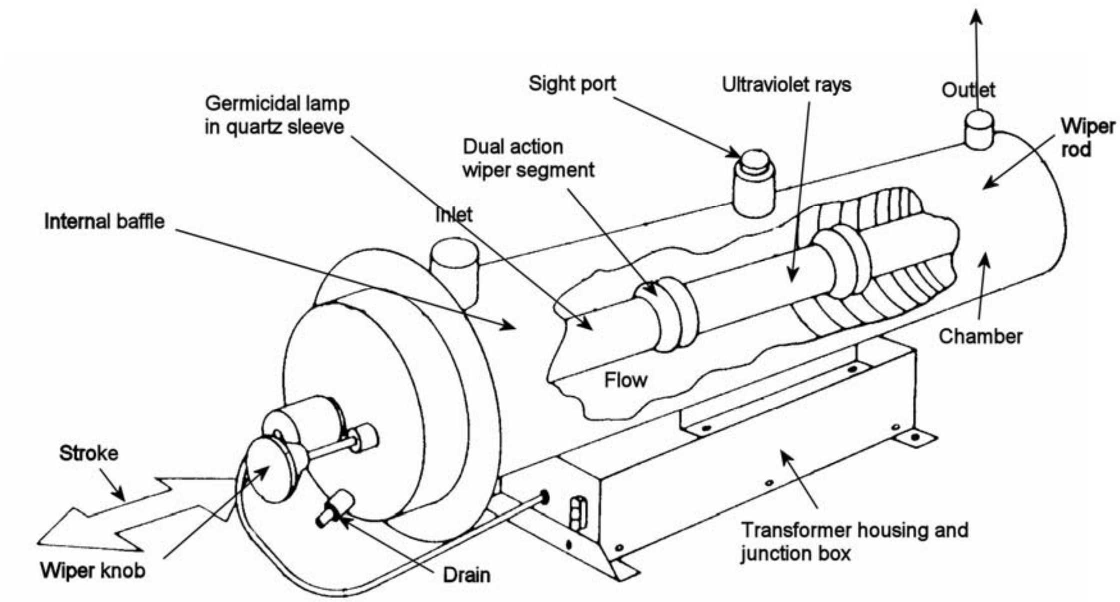

Figure 4-3. Typical ultraviolet disinfection unit (WEF 1985a). Operation of Extended Aeration Package Plants.

The advantages of UV disinfection are that there is no toxic residual, it is effective on a variety of microorganisms, and the UV equipment occupies little space and is relatively inexpensive. The disadvantages of UV are the lack of a measurable residual (which makes immediate control of the process difficult), the lack of methods for measuring dosage, and the need for a lower suspended solids and color concentration in order for it to be effective. For UV disinfection to be effective, wastewater must be relatively clean and clear: UV tubes must be kept submerged and cleaned periodically, and organisms must come into direct contact with the UV light.

Ozone Disinfection

Ozone is not widely used in wastewater disinfection. Ozone is an unstable gas that is produced when oxygen molecules are disassociated into atomic oxygen and then collide with another oxygen molecule. Like chlorine, ozone is a strong oxidizing agent and destroys microorganisms by attacking the cell walls.

Because it is chemically unstable and decomposes to oxygen very rapidly, ozone must be produced continuously and must be used as it is produced. Ozone is bubbled through the effluent in a closed contact chamber with fine bubble diffusers covering the bottom of the chamber. Contact time is generally around 5 minutes. Ozone is then collected off the top of the contact chamber and destroyed.

Ozone is a toxic chemical that can cause severe lasting effects with exposure of more than 1 mg/L. To be effective, ozone disinfection requires high transfer efficiency, good mixing, adequate contact time and minimal short-circuiting in the contactor.

The advantages of using ozone as a disinfectant include the lack of a toxic residual, an increase in effluent dissolved oxygen levels, almost instantaneous disinfection action, and ozone's relative insensitivity to pH. Disadvantages include higher capital and operational costs and a lack of reliable automatic control systems.

4.2 Buffer Zones

A buffer zone is the area beyond the perimeter of a wastewater land application field, which provides the minimum separation needed to reduce the potential for impacts to public health and the environment as well as minimizing nuisance conditions and aesthetic concerns. There are three parts that factor into a site's buffer zone requirements: buffer zone distances to other land uses of concern, posting requirements, and fencing requirements.

Land uses of concern for which DEQ has established guideline buffer zone distances are: areas of public access, surface waters, public or private drinking water supplies and occupied dwellings. The guideline buffer zone distances are a function of the following:

- the characteristics of the land applied wastewater (industrial or municipal)
- level of treatment and disinfection designed for land application site (Class A municipal effluent, industrial)
- location of the land application field (suburban/residential or rural/industrial or residential)
- mode of irrigation (sprinkler or furrow)

For example, allowing spray mist from a wastewater land application sprinkler irrigation system to drift onto adjoining properties has the potential to create aesthetic, nuisance, and public health impacts. General buffer zone distance recommendations for various land uses of concern are as follows:

- Inhabited dwelling: 300 feet
- Private water supply well: 500 feet
- Public water supply well: 1,000 feet
- Public access areas: 50 feet
- Permanent or intermittent surface water: 100 feet
- Temporary surface water and irrigation ditches and canals: 50 feet

In general, DEQ's guideline buffer zone distances decrease with greater disinfection (lower total coliform counts) of the land applied wastewater. In addition, all buffer zone distances must comply with and not supersede local zoning ordinances.

In Section 1, the disinfection levels of the various classes of municipal reclaimed wastewater effluent were presented. The disinfection requirements, with respect to total coliform counts are summarized in Table 4-1.

Table 4-1. Total Coliform Disinfection Requirements for Municipal Reclaimed Wastewater.

Effluent Class	Total Coliform Disinfection Requirement	Compliance Point
Class A and Class B	The median number of total coliform organisms does not exceed two and two-tenths (2.2) per one hundred (100) milliliters, and does not exceed twenty-three (23) per one hundred (100) milliliters in any confirmed sample, as determined from the bacteriological results of the last seven (7) days for which analyses have been completed.	In the distribution system following final treatment, final storage and disinfection contact time.
Class C	The median number of total coliform organisms does not exceed twenty-three (23) per one hundred (100) milliliters, and does not exceed two hundred thirty (230) per one hundred (100) milliliters in any confirmed sample as determined from the bacteriological results of the last five (5) days for which analyses have been completed	At the entrance to the distribution system, following final treatment and disinfection contact time, but before storage.
Class D	The median number of total coliform organisms does not exceed two hundred thirty (230) per one hundred (100) milliliters, not to exceed two thousand three hundred (2300) per one hundred (100) milliliters in any confirmed sample, as determined from the bacteriological results of the last three (3) days for which analyses have been completed	Some location in the treatment process.
Class E	At least primary effluent quality.	

The buffer zone distances specified in a land application permit may vary from DEQ's "guideline" distances due to site specific characteristics. For example, buffer zone distances may be reduced through using mitigation measures, including the following:

- Establishment of an effective physical or vegetative barrier to reduce drift or aerosol dispersion
- Utilization of "non-spray" irrigation (drag tubes or equivalent apparatus)
- Managing irrigation systems in a manner which would prevent any spray drift towards the land use of concern
- Run-off and/or over-spray controls
- Combining Best Management Practices (BMPs) with standard buffer zone distances to help protect drinking water supplies. Monitoring well buffer zone distances are typically less that drinking water well buffer zones and are also dependant on the types of BMPs used. Monitoring well buffer zone distances may vary from site to site and are specified in the site permit.

Example BMPs for wellhead protection include: installation of backflow prevention devices and grading the ground to direct any waters away from a wellhead.

References:

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